CERTIFICATE

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K. Miyashita — Jan. 31, 2004

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[Title of the Invention] ELECTROLUMINESCENT DEVICE

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[List of Documents Attached]

[Name of Document] Specification 1

[Name of Document] Drawings 1

[Name of Document] Abstract 1

[No. of General Power of Attorney] 9711684

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[Name of Document] SPECIFICATION

[Title of the Invention] ELECTROLUMINESCENT DEVICE

[Claims]

[Claim 1] An electroluminescent device having a structure comprising an organic polymer disposed between two electrodes, at least one of the electrodes being transparent, wherein the organic polymer performs light emission in the wavelength range between 400 nm and 600 nm, and wherein the electroluminescent device comprises a thin-film layer disposed between the organic polymer and at least one of the electrodes.

[Claim 2] An electroluminescent device according to Claim 1, wherein the thin-film layer is disposed between a cathode and the organic polymer layer.

[Claim 3] An electroluminescent device according to Claim 2, wherein the thin-film layer is composed of at least one material selected from the group consisting of a fluoride or an oxide of an alkali metal; a fluoride or an oxide of an alkaline earth metal; and a fluoride or an oxide of a group III element in the periodic table.

[Claim 4] An electroluminescent device according to Claim 1, wherein the thin-film layer is disposed between an anode and the organic polymer layer.

[Claim 5] An electroluminescent device according to Claim

4, wherein a positive-hole injection layer or a buffer layer having electrical conductivity, the thickness thereof being not less than 100 nm, is formed as the thin-film layer between the organic polymer layer and the anode.

[Claim 6] An electroluminescent device according to Claim 1, wherein the organic polymer comprises polyfluorene or a derivative thereof.

[Claim 7] An electroluminescent device according to Claim 1, wherein the organic polymer comprises poly(p-phenylenevinylene) or a derivative thereof.

[Claim 8] An electroluminescent device according to Claim 1, wherein the degree of polymerization of the organic polymer is at least two.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

The present invention relates to structures of electroluminescent devices used for displays for terminal components of information apparatuses.

[0002]

[Description of the Related Art]

Recently, development of next generation luminous displays to replace cathode ray tubes (CRT) and liquid crystal displays has been aggressively performed, and research and development of plasma display panels (PDP),

field-emission displays (FED), organic electroluminescence (EL) have also been actively performed. In organic electroluminescent materials, organic polymer materials emitting blue, green, and orange light, have been developed to such a level that the initial characteristics thereof can be utilized (The Society of Fiber Science and Technology, Japan, Symposium Abstracts 1998, 3A11, etc.). Polyfluorene derivatives have been well known as polymer materials for blue light emission, as described in Japanese Journal of Applied Physics, Vol. 30, No. 11B, November, 1991, pp. L1941 - L1943. In addition, as light-emitting materials having wavelengths of green or longer, poly(p-phenylenevinylene) derivatives have been well known, as described in USP 5,247,190.

[0003]

Meanwhile, in electroluminescent devices using light-emitting materials having low molecular weights, it has been reported in Appl. Phys. Lett., 70, 152 (1997) that electron injection efficiency was improved by inserting a cathode interface layer.

[0004]

[Problems to be Solved by the Invention]

However, concerning organic polymer materials for blue light emission, even though the initial characteristics thereof can be satisfactory, there is the problem in that

the wavelength of the luminescent color shifts toward the longer wavelength side with current-application time.

[0005]

Concerning organic polymer materials emitting wavelength of green or longer, satisfactory efficiencies thereof were not obtained.

[0006]

Accordingly, the object of the present invention is to provide an element configuration of electroluminescent devices using organic polymer materials emitting blue, in which changes of luminescent color upon current application are suppressed, and the reliability can be improved. In addition, the present invention provides an element configuration of electroluminescent devices using organic polymer materials emitting wavelength of green or longer, in which satisfactory efficiency thereof can be achieved.

[0007]

[Means for Solving the Problems]

A first means for solving the problems. An electroluminescent device, according to the present invention, has a structure comprising an organic polymer disposed between two electrodes, at least one of electrodes being transparent, in which the organic polymer emits light in the wavelength range between 400 nm and 600 nm, and the electroluminescent device comprises a thin-film layer

disposed between the organic polymer and at least one of the electrodes. According to this configuration, changes of luminescent color with current-application time can be effectively suppressed, and the reliability can be noticeably improved.

[0008]

A second means for solving the problems. The thin-film layer is disposed between a cathode and the organic polymer layer. According to this configuration, unnecessary electron trap levels formed by joining the cathode and the organic polymer layer at the interface thereof, can be avoided.

[0009]

A third means for solving the problems. In the electroluminescent device of the present invention according to the first means for solving the problems, the thin-film layer is composed of at least one material selected from the group consisting of a fluoride or an oxide of an alkali metal; a fluoride or an oxide of an alkaline earth metal; and a fluoride or an oxide of a group III element in the periodic table. According to this configuration, the thin-film layer can be readily formed and changes of luminescent color with time can be readily and effectively suppressed.

[0010]

A fourth means for solving the problems. In the

electroluminescent device of the present invention according to the first means for solving the problems, the thin-film layer is disposed between an anode and the organic polymer layer. According to this configuration, unnecessary positive-hole trap levels formed by joining the anode and the organic polymer layer at the interface thereof, can be avoided.

[0011]

A fifth means for solving the problems. In the electroluminescent device of the present invention according to the fourth means for solving the problems, a positive-hole injection layer or a buffer layer having electrical conductivity, the thickness thereof being not less than 100 nm, is formed as the thin-film layer. According to this configuration, changes of luminescent color with current-application time are effectively decreased.

[0012]

A sixth means for solving the problems. In the electroluminescent device of the present invention according to the fourth means for solving the problems, the organic polymer comprises polyfluorene or a derivative thereof. According to this configuration, the effect of the thin-film layer can be maximized, and changes of luminescent color with time are effectively decreased.

[0013]

A seventh means for solving the problems. In the electroluminescent device of the present invention, the organic polymer comprises poly(p-phenylenevinylene) or a derivative thereof. According to this configuration, the light-emitting efficiency of the electroluminescent device can be noticeably improved.

[0014]

A eighth means for solving the problems. In the electroluminescent device of the present invention according to the first means for solving the problems, the degree of polymerization of the organic polymer is at least two. According to this configuration, film formability of the light-emitting layer is improved, and improvements of reliability and characteristics can be achieved by inserting the thin-film layer.

[0015]

[Description of the Embodiments]

(Example 1) In an electroluminescent device having a structure comprising an organic polymer disposed between two electrodes, at least one of electrodes being transparent, according to this Example, an example will be described in which the organic polymer emits light in the wavelength range between 400 nm to 600 nm and the electroluminescent device comprises a thin-film layer disposed between the organic polymer and the cathode.

In Fig. 1, a simple cross-sectional view of an electroluminescent device of the present invention is shown. As a transparent electrode 2, an indium tin oxide (ITO) film was formed on a transparent glass substrate 1, and was then patterned. Next, as a buffer layer to be used as a thin layer 3, a 100-nm thick film composed of Bytron (Bayer AG) was formed by coating followed by drying thereof. Then, a xylene solution containing one percent of poly(dioctyl)fluorene was coated and dehydrated, and a 50-nm thick film thereof was obtained as a light-emitting layer 4. Subsequently, an ethyl acetate solution containing polymethylmethacrylate (PMMA) was coated and dehydrated, and a 5-nm thick film thereof was obtained as a thin-film layer 5. Calcium was deposited to a thickness of 100 nm as a cathode 6, and aluminum was then deposited to a thickness of 300 nm. Next, in order to form a protective layer 7, the unit thus formed was encapsulated by using a sealing agent and a protective substrate. The light emission spectrum of the blue light-emitting device thus prepared is shown in Fig. 2.

[0016]

In this Example, a polyfluorene derivative was used; however, any organic polymer material which emits blue light has the same effect.

[0017]

When a bank for isolating the cathode is formed after forming and patterning the ITO film, patterning after formation of the cathode is not required. Meanwhile, without forming the bank mentioned above, patterning may be performed using a physical mask during cathode deposition.

[0018]

When active elements, such as thin-film transistors (TFT), are formed on the glass substrate beforehand, a large-scale displaying can be readily performed.

[0019]

In this Example, PMMA was used as the thin-film layer; however, an organic polymer having insulating properties, such as polyethylene, may also be used. In addition, an inorganic material having insulating properties, such as silicon dioxide, may be used as well. Concerning film formation, as well as a coating method, a deposition method or the like may also be employed.

[0020]

In this Example, ITO was used as the transparent electrode; however, a transparent electrode, such as IDIXO sold by Idemitsu K.K and a NESA film, may also be used.

[0021]

In this Example, a glass substrate was used; however, a transparent substrate, such as a plastic, may also be used.

[0022]

In this Example, Bytron was used as the buffer layer; however, materials having electrical conductivity, such as polyaniline, and a phthalocyanine compound, and materials being capable of injecting positive-holes, may also be used.

[0023]

In this Example, calcium was used as the cathode; however, materials having a small work function, such as lithium, magnesium, aluminum, and alloys thereof, may be used as well. Meanwhile, a material having a larger work function compared to that of a transparent electrode, in which driving voltage thereof can be raised, may be used as well.

[0024]

In this Example, an ultraviolet curable epoxy resin was used as the encapsulating agent; however, an encapsulating agent having superior gas barrier properties and humidity resistance may be used as well.

[0025]

(Comparative Example 1) The light emission spectrum of an electroluminescent device without having the thin film layer 5 in Fig. 1 of Example 1, is shown in Fig. 3.

[0026]

(Example 2) In this Example, an example will be described, in which a fluoride or an oxide of an alkali metal; a fluoride or an oxide of an alkaline earth metal; or a

fluoride or an oxide of a group III element in the periodic table, is used for the thin-film layer 5 in Fig. 1. Configurations other than thin-film layer were the same as described in Example 1. As the thin-film layer 5, calcium fluoride film formed to a thickness of 1 nm by deposition was used. The light emission spectrum of the blue light-emitting device thus prepared is shown in Fig. 4.

[0027]

In this Example, calcium fluoride film formed by deposition was used as the thin-film layer; however, lithium fluoride may also be used. In addition, a fluoride or an oxide of an alkali metal element, such as lithium, sodium, or potassium; a fluoride or an oxide of an alkali earth metal element, such as beryllium, magnesium, calcium, or scandium; and a fluoride or an oxide of a group III element in the periodic table, such as boron, aluminum, or gallium, may also be used. In addition, a material that has adequate electrical insulating properties, and easy film formability, may also be used.

[0028]

(Example 3) In this Example, an example will be described in which the organic polymer is poly(p-phenylenevinylene) or a derivative thereof. Configurations other than organic polymer layer was equivalent to that described in Example 1.

[0029]

As the organic polymer layer 4 in Fig. 1, precursors of poly(p-phenylenevinylene) were coated and then baked, and a 100-nm thick film was thereby obtained.

[0030]

The light-emitting efficiency of the electroluminescent device thus prepared was 1.16 lm/W.

[0031]

(Comparative Example) In Comparative Example 1, when a poly(p-phenylenevinylene) film was formed and used as the organic polymer layer in a manner similar to that of Example 3, the light-emitting efficiency thereof was 0.4 lm/W.

[0032]

(Example 4) In this Example, an example will be described in which a positive-hole injection layer or a buffer layer having electrical conductivity was formed between the organic polymer layer and the anode as the thin-film layer 3 in Fig. 1 to a thickness of not less than 100 nm. In Example 1, the electroluminescent devices were prepared by changing the thickness of the positive-hole injection layers from 25 nm to 220 nm, and the chromaticities of these electroluminescent devices measured five minutes after current-application are shown in Fig. 5. It was clear that chromaticity shifted to a blue side with an increase of the thickness of the buffer layer.

[0033]

(Example 5) In this Example, an example will be described in which the degree of polymerization of the organic polymer was changed in Example 1. When the degree of polymerization was changed to 1, 2, and 1,000, film formability of an organic polymer having the degree of polymerization of 1 was seriously inferior. Meanwhile, concomitant with an increase of the degree of polymerization, superior film formability was obtained and an effect by inserting the thin-film layer was enhanced. Even when the degree of polymerization was 2, the effect by the thin-film layer could be observed.

[0034]

[Advantages] According to the present invention as described above, by inserting a thin-film layer between a light-emitting layer composed of an organic polymer and an electrode, a tendency of the luminescent color to shift to longer wavelengths can be suppressed, and a light-emitting efficiency can be noticeably improved. Consequently, the application of organic electroluminescent (EL) displays to information display apparatuses will therefore be accelerated.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 shows a simple cross-sectional view of an electroluminescent device according to the present invention.

[Fig. 2]

Fig. 2 shows a light emission spectrum of a electroluminescent device according to Example 1.

[Fig. 3]

Fig. 3 shows a light emission spectrum of an electroluminescent device according to Comparative Example 1.

[Fig. 4]

Fig. 4 shows a light emission spectrum of an electroluminescent device according to Example 2.

[Fig. 5]

Fig. 5 shows the chromaticity of an electroluminescent device according to Example 4.

[Reference Numerals]

1: substrate

2: anode

3: thin-film layer 1

4: light-emitting layer

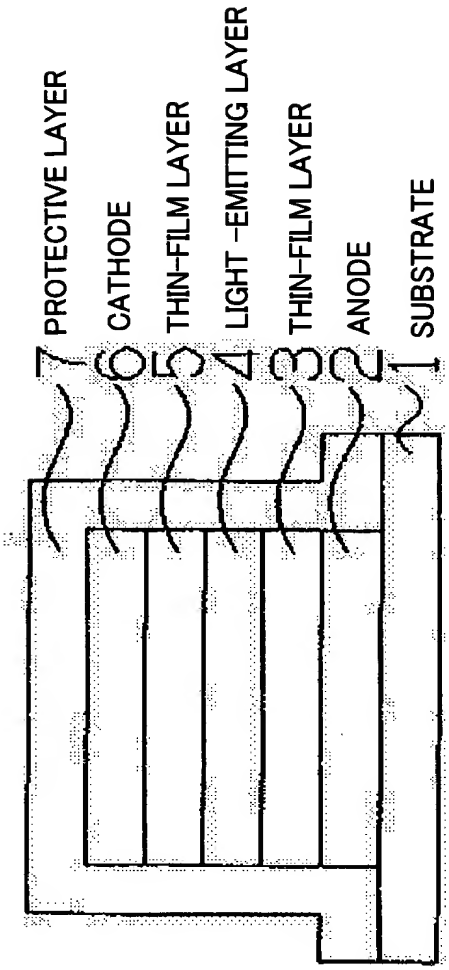
5: thin-film layer 2

6: cathode

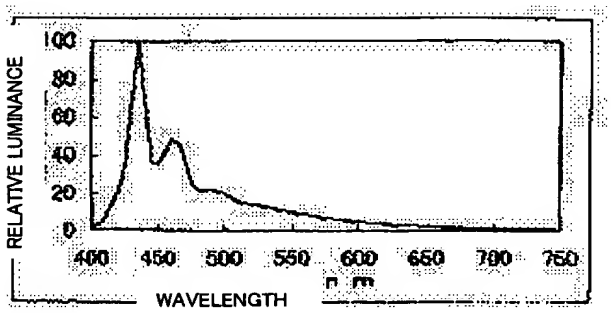
7: protective layer

【Name of Document】 Drawings

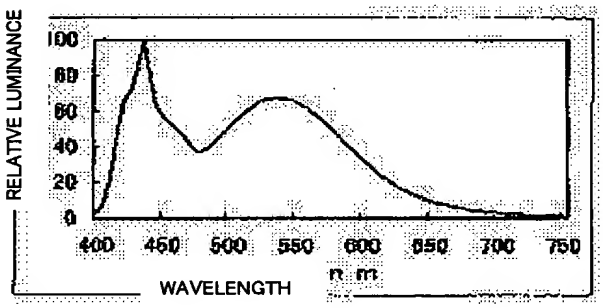
【FIG. 1】



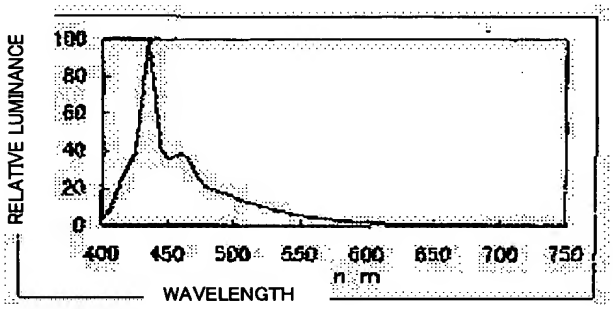
【FIG. 2】



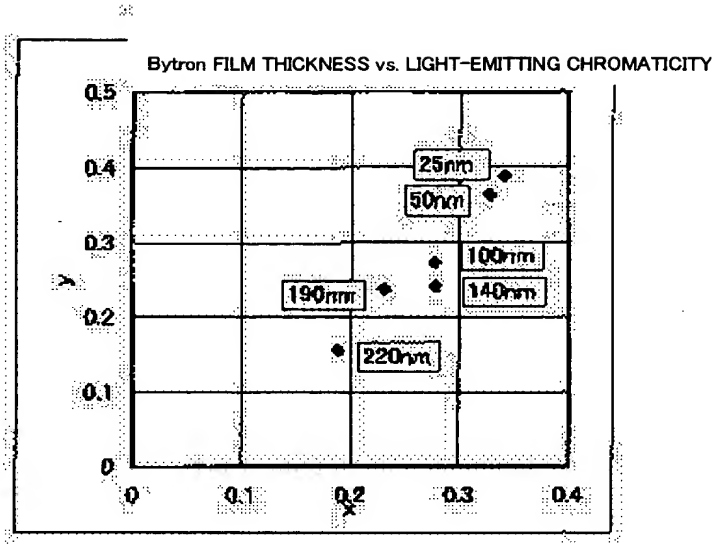
【FIG. 3】



【FIG. 4】



【FIG. 5】


Bytron FILM THICKNESS vs. LIGHT-EMITTING CHROMATICITY
0.5
0.4
0.3
0.2
0.1
0
y
0
0.1
0.2
0.3
0.4
x
25nm
50nm
100nm
140nm
190nm
220nm

[Name of Document] ABSTRACT

[ABSTRACT]

[Object] Conventional blue light-emitting devices composed of organic polymers have the problem in that changes in luminescent color with time are large.

[Solving Means] In an electroluminescent device using an organic polymer, by inserting a thin-film layer between the light-emitting organic polymer layer and an electrode, the tendency of luminescent color to shift to longer wavelengths can be suppressed, and the light-emitting efficiency can be noticeably improved.

[Selected Figure] Fig. 1